Plasmonic photonic crystals for a new generation of infrared sources and spectroscopic sensors

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Sensors of trace gases are of enormous importance to diverse fields such as environmental protection, household safety, bio-hazardous material identification, meteorology and industrial environments. IR sensors make up a significant part of the gas-sensor instrumentation market, and IR spectroscopy sensors remain the most accurate and reliable because they do not rely on catalytic or electrochemical interactions. Drawbacks of the existing IR gas sensors are their complicated multi-element instrumentation design and their cost.

We propose a new class of IR gas sensors, where the enabling technology is a spectrally tuned plasmonic photonic crystal. Building both the emitting and sensing capabilities on to a single discrete element, Ion Optics' infrared sensorchip brings together a new sensor paradigm to vital commercial applications. We exploit the interaction between surface plasmons at a metal interface with a photonic crystal in silicon to control the spectral response of the surface in reflection, absorption and emission. The unique design uses Si-based thermally isolated suspended bridge structures fabricated using conventional photolithography techniques. The tunable narrow spectral response is defined by the symmetry and periodicity of the metallodielectric photonic crystal. Individual sub-resonances are recognized within this bandwidth. We model their origin through calculations of surface plasmon modes in the metallic grating overlayer. Thin metal layers lead to coupled plasmons at the two metal-dielectric interfaces, that in turn couple to modes in the underlying silicon-air photonic crystal. The effects of lattice type, angle of incidence, etch depth, metal and dielectric properties have been studied. Defects engineered into the photonic crystal lattice provide further improvements for the efficiency of the device and its application to a new generation of infrared sources and spectroscopic sensors.